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Analysis of the entrance requirements to the...

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ANALYSIS OF THE ENTRANCE REQUIREMENTS TO THE COLLEGE OF ENGINEERING AND ARCHITECTURE UNIVERSITY OF MINNESOTA

A THESIS
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA

BY

ARWOOD STANLEY NORTHBY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
JUNE 1935

Aug. 12, 1938. 121

RANK IN HIGH SCHOOL SCHOLARSHIP AS A REQUIREMENT FOR ENTRANCE INTO THE COLLEGE OF ENGINEERING AND ARCHITECTURE*

The College of Engineering and Architecture, University of Minnesota, has long required, as a part of the student's matriculation, information concerning his scholarship rank in the high school graduating class.[1] Previous to the fall of 1932 the rank had never been used as an entrance criterion, but beginning with that year only those students in the upper 60 per cent of their high school graduating class, as ranked on the basis of average scholarship, were admitted to the college. It is the purpose of this study to examine this ruling. Does this requirement assist in the selection of good college risks and the elimination of poor ones? Is there any other percentile rank in high school scholarship which would be more effective in the discrimination of the potentially successful from the potentially unsuccessful college student?

The first step in making this study was to classify into deciles on the basis of percentile rank in high school scholarship those students who entered the college during the four years immediately preceding the inauguration of the new ruling.[2] The second step was to compare these ten groups on the basis of their success in college as measured by first quarter and first year honor point ratios and by per cent graduating from college.[3]

The subjects included all students entering the College of Engineering and Architecture from Minnesota high schools during the four-year period from 1928-29 to 1931-32, who were entering college for the first time, and for whom complete data were to be had—a total of 951 students. These students were not subject to the regulation under which scholastic rank in the high school graduating class became a criterion for entrance into the College of Engineering and Architecture.

When the students were classified according to year of entrance and high school scholarship decile, it was found that the larger percentages came from the upper deciles of the high school graduating classes. The

[1] In connection with the administration of the Minnesota College Aptitude Test, the various high schools of the state annually send to the University Testing Bureau lists of the graduating seniors ranked according to the average mark earned in high school up to the beginning of the second semester of the senior year. By means of the formula, $1 - \frac{\text{Rank in class}}{\text{Number in class}}$, these ranks are transmuted into percentile scores.

[2] The term decile will refer throughout this report to the high school scholarship decile.

[3] These ratios were calculated by assigning an arbitrary numerical value to each mark and dividing the total of these values by the total number of hours of credit for which the student was registered. The scale of numerical values assigned to the marks was as follows: A = 4, B = 3, C = 2, D = 1, and F = 0. For convenience the results were then multiplied by 100.

* These three studies are excerpts form *Minnesota Studies in Articulation*, University Committee on Educational Research, M. E. Haggerty, chairman. Minneapolis: University of Minnesota, 1937. The complete thesis is on file in the library of the University of Minnesota.

TABLE I

DISTRIBUTION OF THE HONOR POINT RATIOS FOR THE FIRST QUARTER MADE BY STUDENTS IN THE VARIOUS HIGH SCHOOL SCHOLARSHIP DECILES, COLLEGE OF ENGINEERING, AND ARCHITECTURE, SCHOOL YEARS 1928-29 TO 1931-32

Decile Rank in High School Scholarship	Honor Point Ratios First Quarter: 0	1 to 25	26 to 50	51 to 75	76 to 100	101 to 125	126 to 150	151 to 175	176 to 200	201 to 225	226 to 250	251 to 275	276 to 300	301 to 325	326 to 350	351 to 375	376 to 400	Total No. Cases	Mean
91-100	0	0	0	3	4	9	7	10	24	20	19	8	19	4	6	0	3	136	217.17
81- 90	1	1	0	5	7	11	17	16	19	17	15	8	9	3	1	3	0	133	188.21
71- 80	1	2	6	10	19	18	17	20	17	14	10	8	0	3	1	0	0	146	152.10
61- 70	0	2	6	11	16	11	20	15	11	5	5	9	0	0	1	0	0	112	141.84
51- 60	0	4	12	13	7	15	14	11	6	3	0	1	0	0	0	0	0	86	109.73
41- 50	3	6	8	14	17	16	10	14	7	4	2	1	0	0	1	1	0	104	114.31
31- 40	5	5	6	19	12	8	12	7	4	2	1	1	1	0	0	0	0	83	99.43
21- 30	2	5	6	12	10	12	9	4	3	0	0	0	0	0	0	0	0	63	91.64
11- 20	1	6	11	11	12	4	4	8	1	0	2	0	0	0	0	0	0	60	87.44
1- 10	2	8	7	2	4	1	1	0	1	0	1	0	0	0	1	0	0	28	67.00

first four deciles, which compose the group now excluded by the new ruling, contained 234, or 24.6 per cent, of the entrants during the period under consideration. Other than a slight decrease in the percentages coming from the lower deciles in 1931-32 and a slight increase in the percentages coming from the upper deciles the same year, there were no outstanding changes during the four years.

If the new admission requirement had been enforced during the four-year period under consideration, the students in the four lowest deciles would not have been admitted. As already indicated, there were 234 students, or 24.6 per cent of the entire number, who were included in these four deciles. What has been the success of these students in college? Was the nature of their work such as to justify the use of the fortieth percentile in high school scholarship as a crucial point for admittance to college? Some light on these questions is presented in the following paragraphs.

The first measure of the college success of the students is the first quarter honor point ratio. The ratios were tabulated according to scholarship deciles, the results being shown in Table I. With one exception (the sixth decile) there was a continuous increase in the size of the mean ratios from the first to the tenth decile. None of the differences between the mean ratios of the deciles were statistically significant below the seventh decile (Table II).[4]

TABLE II

RATIOS OF THE DIFFERENCE BETWEEN MEAN FIRST QUARTER HONOR POINT RATIOS TO THE STANDARD ERROR OF THE DIFFERENCES, STUDENTS GROUPED ACCORDING TO DECILE RANK IN HIGH SCHOOL SCHOLARSHIP

Decile Rank in High School Scholarship	81-90	71-80	61-70	51-60	41-50	31-40	21-30	11-20	1-10
91-100	3.37	7.89	8.69	12.70	11.51	12.95	14.68	13.83	9.43
81- 90		4.30	5.27	9.13	8.16	9.63	11.13	10.61	7.58
71- 80			1.21	5.13	4.32	5.92	7.24	7.03	5.38
61- 70				3.70	3.01	4.57	5.73	5.68	4.67
51- 60					0.51	1.13	2.11	2.37	2.68
41- 50						1.56	2.51	2.74	2.92
31- 40							0.85	1.20	1.99
21- 30								0.44	1.54
11- 20									1.24

A comparison of the scholarship deciles on the basis of their mean honor point ratios alone gives an incomplete picture, for many students

[4] Differences between means are not considered statistically significant, i.e., not due to chance errors of measurement, unless the observed difference is equal to at least three times the standard error of the difference between the means.

in the first four deciles received honor point ratios which were higher than those received by many in the upper six deciles. To put it in other words, the amount of overlapping of the several distributions was considerable. As a measure of the amount of overlapping, the percentages exceeding and falling below the median of the fifth or critical decile were calculated, the data being presented in Table III. The improvement of one group over another is regular and continuous from the first to the tenth decile. The difference between the first and tenth deciles is considerable; 17 per cent of the students in the former as contrasted with 93.2 per cent in the latter had honor point ratios above the median ratio of the fifth decile. It was found that 26.53 per cent of the students in the first four deciles had first quarter honor point ratios above, and 73.47 per cent had ratios below, the median of the fifth decile. When the students in the five deciles above the fifth were grouped together, it was found that 76.2 per cent exceeded, and 23.8 per cent fell below, the median honor point ratio of the fifth decile.

TABLE III

PER CENT OF THE STUDENTS IN THE VARIOUS HIGH SCHOOL SCHOLARSHIP DECILES ABOVE AND BELOW THE MEDIAN FIRST QUARTER HONOR POINT RATIO OF DECILE FIVE, AND RELATED DATA

DECILE RANK IN HIGH SCHOOL SCHOLARSHIP	FIRST QUARTER HONOR POINT RATIOS		
	N	Per Cent Below*	Per Cent Above*
91-100	136	6.8	93.2
81- 90	133	12.6	87.4
71- 80	146	29.1	70.9
61- 70	112	33.7	66.3
51- 60	86	46.2	53.8
41- 50	104	50.0	50.0
31- 40	83	59.0	41.0
21- 30	63	60.3	39.7
11- 20	60	70.0	30.0
1- 10	28	83.0	17.0

* Median of decile five (41-50) is 107.25.

In the preceding discussion the analysis has been confined to a comparison of groups. A study of the individual records reveals a fair number of instances of successful work accomplished by students in the lower deciles (Table I). For example, one student in the first decile earned an honor point ratio equivalent to a mark of B; only seventeen students, distributed throughout the remaining nine deciles, did as well as or better than this student.

The second measure of college success is the first year honor point ratio. Many students who were included in the analysis of the first

TABLE IV

HONOR POINT RATIOS FOR THE FIRST YEAR MADE BY STUDENTS IN THE VARIOUS HIGH SCHOOL SCHOLARSHIP DECILES, COLLEGE OF ENGINEERING AND ARCHITECTURE, SCHOOL YEARS 1928-29 TO 1931-32

DECILE RANK IN HIGH SCHOOL SCHOLARSHIP	FIRST YEAR HONOR POINT RATIOS															TOTAL NO. CASES	MEAN
	1 to 25	26 to 50	51 to 75	76 to 100	101 to 125	126 to 150	151 to 175	176 to 200	201 to 225	226 to 250	251 to 275	276 to 300	301 to 325	326 to 350	351 to 375	376 to 400	
91-100	0	0	0	0	10	15	10	19	16	21	13	6	11	7	0	2	130	220.03
81- 90	0	0	1	2	11	16	16	18	14	18	4	9	6	1	1	0	117	198.53
71- 80	0	0	5	7	20	22	20	23	15	4	5	3	0	2	0	0	126	165.68
61- 70	0	0	4	12	16	24	11	11	9	4	2	1	1	0	0	0	95	150.75
51- 60	0	0	4	10	11	15	16	4	1	0	0	0	0	0	0	0	61	131.94
41- 50	0	0	5	6	29	14	13	5	4	1	1	1	0	1	0	0	80	139.12
31- 40	0	3	8	21	12	8	8	3	3	0	0	0	0	0	0	0	66	113.13
21- 30	0	0	5	14	6	12	5	1	0	0	0	0	0	0	0	0	43	114.08
11- 20	0	3	1	10	11	7	1	4	0	0	0	0	0	0	0	0	37	113.50
1- 10	1	2	2	6	3	0	1	0	1	0	0	1	0	0	0	0	17	103.21

quarter honor point ratios left college before the end of their first year. The percentages of the remaining 772 students who completed three quarters or more of college work and who were, therefore, included in the study of the first year honor point ratios, were as follows:

Decile	Per Cent
91-100	95.58
81- 90	87.96
71- 80	86.30
61- 70	84.82
51- 60	70.93
41- 50	76.92
31- 40	79.51
21- 30	68.25
11- 20	61.76
1- 10	60.71

The honor point ratios for the first three quarters for the 772 students are shown in Table IV. Proceeding from the first to the tenth decile the ratios, except for the fourth and sixth, show continuous improvement. The mean ratios of the second, third, and fourth deciles are much the same. The mean ratios of the first four deciles, which include those students who would not be admitted under the new requirement, are noticeably lower than the ratios of the upper six groups. Furthermore, the ratios of the differences between the means to the standard error of the differences, as presented in Table V, show that all differences between the mean ratios above the fourth decile are significant.

TABLE V

Ratios of the Difference between Mean First Year Honor Point Ratios to the Standard Error of the Difference, Students Grouped According to Decile Rank in High School Scholarship

Decile Rank in High School Scholarship	81-90	71-80	61-70	51-60	41-50	31-40	21-30	11-20	1-10
91-100	6.57	17.79	21.89	29.73	25.25	33.93	34.36	30.91	16.97
81- 90		10.87	15.26	22.74	18.74	27.39	27.69	24.89	13.88
71- 80			5.14	12.57	9.01	18.18	18.32	16.26	9.23
61- 70				6.70	3.80	12.51	12.49	11.24	6.97
51- 60					2.52	6.73	6.57	5.91	4.27
41- 50						8.53	8.41	7.64	5.25
31- 40							.33	.11	1.46
21- 30								.18	1.60
11- 20									1.48

When the distributions of the ten deciles are compared on the basis of the extent of overlapping, the superiority of the upper six deciles is again evident (Table VI). Of the lower four deciles the third appears

better than the fourth, and between the second and fourth there is little difference. One third to two fifths of the students in the second, third, and fourth scholarship deciles earned honor point ratios which exceeded the median honor point ratio of the crucial decile group, the fifth.

TABLE VI

Per Cent of the Students in the Various High School Scholarship Deciles Above and Below the Median First Year Honor Point Ratio of Decile Five, and Related Data

Decile Rank in High School Scholarship	First Year Honor Point Ratios		
	N	Per Cent Below*	Per Cent Above*
91-100	130	7.7	92.3
81- 90	117	12.0	88.0
71- 80	126	25.4	74.6
61- 70	95	33.7	66.3
51- 60	61	41.0	59.0
41- 50	80	50.0	50.0
31- 40	66	66.7	33.3
21- 30	43	58.1	41.9
11- 20	37	67.6	32.4
1- 10	17	82.4	17.6

* The median of decile five (41-50) is 126.0.

TABLE VII

Number and Per Cent of the 1928 Entrants Who Had Received Degrees by December, 1933, Classified According to Percentile Rank in High School Scholarship, College of Engineering and Architecture

Decile Rank in High School Scholarship	Number in Original Group	Number of Quarters Attended by Those Who Were Graduated from College							
		11	12	13	14	15	16	Total	Per Cent
91-100	29	0	11	1	3	0	0	15	51.6
81- 90	30	1	6	2	3	1	1	14	46.6
71- 80	32	0	9	1	0	3	1	14	43.7
61- 70	18	0	4	1	0	1	0	6	33.3
51- 60	27	0	0	1	3	1	0	5	18.5
41- 50	25	0	2	0	0	3	1	6	24.0
31- 40	18	0	1	1	1	0	0	3	16.7
21- 30	10	0	1	0	0	0	0	1	10.0
11- 20	15	0	1	0	0	1	0	2	13.3
1- 10	13	0	1	0	0	0	0	1	7.7
Total	217	1	36	7	10	10	3	67	30.8

The third measure of college success employed in this study is graduation from college. The number and per cent of the 1928 entrants, arranged according to high school scholarship deciles, who had been

graduated from college by December, 1933, are shown in Table VII. With few exceptions, the percentage of the students who received degrees increased from the first to the tenth decile. The percentages in the lowest four deciles of the 1928 group ranged from 7.7 to 16.7, while in the upper six deciles the percentages ranged from 18.8 to 51.6. Five years after the date of entrance, 7, or 12.5 per cent, of the 56 students who originally composed the lower four groups had received degrees.

Data for the 1929 entrants are presented in Table VIII. The tendency for larger percentages of the students in the upper scholarship deciles to graduate is again evident. A lower percentage for the fifth decile than for the fourth is about the only outstanding exception. Four years after entering college, 3, or 4.4 per cent, of the 68 students composing the lower four deciles of the 1929 group had received degrees.

TABLE VIII

NUMBER AND PER CENT OF THE 1929 ENTRANTS WHO HAD RECEIVED DEGREES BY DECEMBER, 1933, CLASSIFIED ACCORDING TO PERCENTILE RANK IN HIGH SCHOOL SCHOLARSHIP, COLLEGE OF ENGINEERING AND ARCHITECTURE

Decile Rank in High School Scholarship	Number in Original Group	Number of Quarters Attended by Those Who Were Graduated from College				
		11	12	13	Total	Per Cent
91-100	37	0	19	1	20	54.1
81- 90	38	1	10	0	11	28.9
71- 80	39	0	7	0	7	17.9
61- 70	27	1	3	0	4	14.8
51- 60	19	0	1	2	3	15.8
41- 50	28	0	1	1	2	7.1
31- 40	19	0	2	0	2	10.5
21- 30	23	0	0	1	1	4.3
11- 20	18	0	0	0	0	0.0
1- 10	8	0	0	0	0	0.0
Total	256	2	43	5	50	19.5

PREDICTION OF SCHOLASTIC SUCCESS IN THE COLLEGE OF ENGINEERING AND ARCHITECTURE

For several years the College of Engineering and Architecture at the University of Minnesota has collected information regarding the abilities of its entrants. Included among these data are the percentile rank on the Minnesota College Aptitude Test, percentile rank in high school scholarship, and scores on six Iowa Placement tests. It is the purpose of this study to present material showing the accuracy of these measures in predicting scholastic success in the College of Engineering and Architecture.

The nature of these measures and the method of gathering the data for this study may be briefly described as follows. The College Aptitude Test is an intelligence test given each spring to all seniors in the high schools of Minnesota as a part of a testing program sponsored by the Minnesota Association of Colleges. This test is scored by the University Testing Bureau, the organization which annually conducts the testing program for the association.

The six Iowa Placement tests from which data are available for this study are: (1) Mathematics-Aptitude, Series MA1, Revised, A; (2) Mathematics-Training, Series MT1, Revised, A; (3) Chemistry-Aptitude, Series CA1, Revised, A; (4) Chemistry-Training, Series CT1, Revised, A; (5) English-Aptitude, Series EA1, Revised; and (6) English-Training, Series ET1, Revised, A.

Since 1924, the first five of the above examinations have been given annually during Freshman Week to all students entering the College of Engineering and Architecture. The tests were administered and scored by the faculty members of the college in accordance with instructions given with the tests. The English Training Test has been given each spring to all graduating seniors in the high schools of the state in conjunction with the College Aptitude Test, and has been scored by the University Testing Bureau.

The criteria of college success used in this study consisted of the first quarter and first year honor point ratios.

Two groups of students formed the subjects of this study. One consisted of all the 1928 fall entrants to the freshman class of the College of Engineering and Architecture for whom complete data were to be had. In this class, hereafter called the 1928 group, 162 cases completed the first quarter and 128 the first year. These students were unselected

save that they were graduates of Minnesota high schools and were entering college for the first time. The other, hereafter called the 1931 group, included all those students entering the freshman class of the College of Engineering and Architecture in the fall of 1931 who not only came from Minnesota high schools and were entering college for the first time but also had taken chemistry, advanced algebra, and solid geometry in high school. There were 138 students in this group who completed the first quarter and 122 who completed the first year.

The method used in this study consisted in calculating zero-order coefficients of correlation and the coefficients of multiple correlation between the various predictive measures and the criteria of college success. The predictive value of each of the eight measures was determined by the size of the zero-order coefficient, and the total predictive value of the eight measures by the coefficient of multiple correlation. The contribution of each measure to the total prediction was indicated by the regression coefficients. The probable error was used to show the accuracy of prediction of the zero-order coefficients, while the probable error of estimate was used to show the accuracy of prediction of the coefficients of multiple correlation.

Raw scores on the Iowa tests were used in calculating the correlations between these measures and the criteria for both the 1928 and the 1931 groups. The percentile ranks in the high school graduating class and in the College Aptitude Test were used in calculating all coefficients for the 1928 group. For the 1931 group, however, these percentile ranks were converted into standard deviation scores. Tables devised by Karl Holzinger for this purpose were used.[1]

In Table I are shown the zero-order coefficients of correlation between college success and the eight predictive factors for the 1928 group of students. When college success is measured by the first quarter honor point ratio these coefficients range from .5493 to .3369, and when measured by first year honor point ratio the range is from .4979 to .2747. High school scholarship, the Mathematics Training and the Mathematics Aptitude tests correlate highest with either the first quarter or first year criterion. The correlations with Chemistry Training and English Aptitude tests are the lowest. In all instances the coefficients for the first year honor point ratio were less than those for the first quarter honor point ratio. These decreases are not surprising when one learns that the range in college scholarship of the subjects used for the first year criterion was much less than that of the subjects used for the first quarter criterion. This decrease in range of college scholarship was caused by the elimination from college of students who did poorly

[1] Karl Holzinger, *Statistical Tables for Students in Education and Psychology*, pp. 72-74. Chicago: University of Chicago Press. 1932.

in their courses, and whose honor point ratios would therefore tend to be low. It is a well-recognized fact that decreasing the range of a variable results in a decreased correlation coefficient. The amount of the elimination is shown by the fact that the 162 cases in the first quarter group had been reduced to 128 cases by the end of the first year. A study of the individual records showed that most of the students who left school came from the lower scholastic levels. Furthermore, a comparison of the mean honor point ratio for the first quarter with the mean honor point ratio for the first year shows an increase from 1.5501 to 1.9084.

TABLE I

COEFFICIENTS OF CORRELATION, PEARSON r, BETWEEN FIRST QUARTER COLLEGE HONOR POINT RATIO AND FIRST YEAR HONOR POINT RATIO AND EIGHT SELECTED PREDICTIVE MEASURES USED IN PREDICTING THE RATIOS FOR THE 1928 GROUP OF STUDENTS, COLLEGE OF ENGINEERING AND ARCHITECTURE

PREDICTIVE MEASURE	COEFFICIENTS OF CORRELATION WITH COLLEGE HONOR POINT RATIOS					
	First Quarter			First Year		
	r	P.E.	No. cases	r	P.E.	No. cases
High school scholarship	.5493	.0378	162	.4814	.0474	128
English Aptitude	.3369	.0472	162	.3015	.0560	128
English Training	.4906	.0400	162	.4708	.0474	128
Mathematics Aptitude	.5399	.0378	162	.4978	.0462	128
Mathematics Training	.5484	.0378	162	.4979	.0462	128
Chemistry Aptitude	.4973	.0400	162	.4753	.0474	128
Chemistry Training	.3838	.0456	162	.2747	.0567	128
College Aptitude	.4648	.0420	162	.4010	.0517	128

In Table II are shown the zero-order coefficients of correlation between college success and the eight predictive measures for the 1931 group of students. When college success is measured by first quarter honor point ratio these coefficients range from .6951 to .5012, and when measured by first year honor point ratio the range is from .6901 to .3662. It will be observed that the highest coefficients for the first quarter were obtained when correlated with high school scholarship, Mathematics Aptitude, Mathematics Training, and Chemistry Aptitude tests. In predicting first year honor point ratio, the high school scholarship, Mathematics Training and Mathematics Aptitude tests produced the highest correlations. For both the first quarter and the first year groups the English Aptitude and College Aptitude tests gave the lowest correlations. All except one of the coefficients decreased when first year honor point ratio was considered, the one exception being high school scholarship which showed a slight increase.

TABLE II

COEFFICIENTS OF CORRELATION, PEARSON r, BETWEEN FIRST QUARTER COLLEGE HONOR POINT RATIO AND FIRST YEAR HONOR POINT RATIO AND EIGHT SELECTED PREDICTIVE MEASURES USED IN PREDICTING THE RATIOS FOR THE 1931 GROUP OF STUDENTS, COLLEGE OF ENGINEERING AND ARCHITECTURE

PREDICTIVE MEASURE	COEFFICIENTS OF CORRELATION WITH COLLEGE HONOR POINT RATIOS					
	First Quarter			First Year		
	r	P.E.	No. cases	r	P.E.	No. cases
High school scholarship	.6528	.0322	138	.6901	.0314	122
English Aptitude	.5025	.0428	138	.4039	.0517	122
English Training	.5592	.0391	138	.4945	.0462	122
Mathematics Aptitude	.6263	.0351	138	.5230	.0449	122
Mathematics Training	.6951	.0291	138	.6541	.0348	122
Chemistry Aptitude	.6322	.0337	138	.4755	.0474	122
Chemistry Training	.5548	.0391	138	.4611	.0485	122
College Aptitude	.5012	.0428	138	.3662	.0536	122

A comparison of the data for the 1928 group with that for the 1931 group shows higher coefficients for the latter in every instance but one. When one considers the fact that the 1928 group was unselected and that it included students with varying degrees of high school training in two of the fields of learning—chemistry and advanced mathematics—while the 1931 group was limited to students who had high school courses in these fields, these results are partly accounted for. Refining the scores for ranks in high school scholarship may have assisted in increasing the size of the coefficients obtained. The relative positions of the various predictive factors were approximately the same in all four calculations. Altho the order did not remain constant, high school scholarship, Mathematics Aptitude and Mathematics Training tests tended to produce the highest correlations with the criteria, the only exception being in the 1931 first quarter group, where the Chemistry Aptitude Test slightly exceeded the coefficients obtained for the Mathematics Training Test.

The coefficients of multiple correlation between the eight predictive factors and the two criteria of college success for the 1928 and 1931 groups of students were then calculated. The coefficient of multiple correlation is that coefficient which gives the maximum prediction when the several measures are combined in such a way that each contributes its maximum amount to the total. Between the criterion and the eight measures for the 1928 first quarter group this coefficient was .7053. This is an increase of approximately fifteen points over the highest zero-order coefficient for this group. The accuracy of the prediction is indicated by the probable error of estimate which indicates the limits

within which half of the errors will fall. The probable error of estimate for the obtained coefficient of multiple correlation was .4087. This means that half of the estimated scores will not vary from the true scores by more than 409 points. It will be remembered that the range in honor points was from 0 to 4.

The coefficient of multiple correlation between the eight measures and the first year honor point ratio, 1928 group, was .6780, with a probable error of estimate of .3364. This coefficient is slightly smaller than that obtained from the first quarter 1928 group. In most instances a decreased coefficient of multiple correlation is accompanied by an increased probable error of estimate in view of the nature of the probable error of estimate.[2] One need not look far for the cause of the variation. The primary reason is the decrease in the size of the standard deviation of the distribution of the first year honor point ratio. The chief cause for this again is the decrease in the range of scholarship, those students in the lower levels tending to be eliminated.

The coefficient of multiple correlation for the 1931 group between the eight predictive factors and first quarter honor point ratio was .8269, $P.E._{est.}$ .3030, and between these measures and first year honor point ratio was .8003, $P.E._{est.}$ .3021. Both of these coefficients of multiple correlation show an increase over the two obtained for the 1928 group. Since the coefficient of multiple correlation is based upon the zero-order coefficients, the fact that the zero-order coefficients for the 1931 group were larger than those for the 1928 group accounts for this result. As was previously noted, selecting students in the 1931 group upon the basis of high school courses in chemistry and advanced mathematic, and refining the measures of high school scholarship were considered the major reasons for the larger 1931 group zero-order coefficients.

The relative significance or weight which should be assigned to each of the eight variables in the prediction of the criterion of college success by means of the coefficient of multiple correlation is indicated by the regression coefficient. In Table III are presented the regression coefficients calculated for the two 1928 and the two 1931 coefficients of multiple correlation which have already been discussed. It is at once manifest from an examination of this table that high school scholarship contributes most in the calculation of the coefficients. In every instance it ranks first. This is accounted for statistically by the fact that the zero-order coefficients between high school scholarship and the criteria of college success were uniformly high, and at the same time the intercorrelations between high school scholarship and the other variables were low. This means, however, that high school scholarship as meas-

[2] The formula for computing the probable error of estimate is:

$$P.E._{est.} = .6745\ S.D.\ \sqrt{1 - r^2}$$

ured by teachers' marks is a better instrument to predict college success for these groups of students than any of the other measures used. The Mathematics Training Test ranks next in order as the most consistent predictive measure for any of these groups of students. The weights of the measures show considerable variation in the four sets of calculations, except the College Aptitude Test, which appears consistently to be of little weight in all four instances. This does not mean that intelligence has little weight in determining college success, but rather that whatever was measured by this test was included in the other measures used.

TABLE III

REGRESSION COEFFICIENTS OBTAINED IN COMPUTING THE COEFFICIENTS OF MULTIPLE CORRELATION BETWEEN EIGHT SELECTED FACTORS AND FIRST QUARTER AND FIRST YEAR HONOR POINT RATIOS FOR THE 1928 AND 1931 GROUPS OF STUDENTS, COLLEGE OF ENGINEERING AND ARCHITECTURE

PREDICTIVE MEASURES	REGRESSION COEFFICIENTS			
	1928 Group		1931 Group	
	First quarter R	First year R	First quarter R	First year R
High school scholarship	.3504	.3305	.3830	.4935
Mathematics Aptitude	.2531	.2792	.0778	.0504
Mathematics Training	.1680	.1467	.2792	.3674
English Aptitude	.0085	−.0178	.2745	.1047
English Training	.1448	.2264	−.0176	.1417
Chemistry Aptitude	.0099	.1364	.0962	−.1459
Chemistry Training	−.0364	−.2317	.0528	.0702
College Aptitude	.0245	−.0347	−.0545	−.1151

A comparison of the regression coefficients calculated for the 1928 group with those for the 1931 group, with two exceptions, shows no great relative changes. The coefficients for the English Aptitude Test increased in 1931 over 1928, while at the same time those for the Mathematics Aptitude Test decreased. The other differences between the regression coefficients computed for the 1928 and those for the 1931 group appear no greater than do the differences between first quarter and first year predictions.

The purpose of this study was to find the combination of measures which would most accurately predict scholastic success in the freshman year of the College of Engineering and Architecture. From an administrative standpoint, however, it is not economical to use as many measures as are combined in the multiple correlations reported heretofore if a smaller number will result in a prediction which is equally valid. Consequently an effort was made to discover those combinations of measures

which would appear to be most feasible for practical use. In view of the fact that the correlations for the 1931 group were consistently higher than those for the 1928 group, this aspect of this study was confined to the data from the 1931 group.

Since the rank in high school scholarship tended to correlate fairly high with the criterion and relatively low with the various other measures, this item was combined with each of the tests (Table IV). The combination of high school scholarship and the Mathematics Training Test was found to have the highest predictive value, the coefficient with the first quarter honor point ratio being .7726 and with the first year .7755. The stability of this combination is rather noteworthy, the correlation with the first year honor point ratio actually increasing slightly. The combination of high school scholarship and the English Aptitude Test ranked second in order; that for high school scholarship and the College Aptitude Test ranked the lowest.

TABLE IV

MULTIPLE COEFFICIENTS OF CORRELATION BETWEEN FRESHMAN FIRST QUARTER AND FIRST YEAR HONOR POINT RATIOS AND THE COMBINATION OF HIGH SCHOOL SCHOLARSHIP WITH EACH OTHER MEASURE, STUDENTS ENTERING FALL QUARTER, 1931, COLLEGE OF ENGINEERING AND ARCHITECTURE

VARIABLES	FIRST QUARTER HONOR POINT RATIO	FIRST YEAR HONOR POINT RATIO
High school scholarship and English Aptitude	.7644	.7295
High school scholarship and English Training	.7232	.7375
High school scholarship and Mathematics Aptitude	.7468	.7223
High school scholarship and Mathematics Training	.7726	.7755
High school scholarship and Chemistry Aptitude	.7394	.7050
High school scholarship and Chemistry Training	.7305	.7254
High school scholarship and College Aptitude	.7016	.7002

Since high school scholarship and the Mathematics Training Test appeared to be the best of these combinations for predicting scholastic success in the College of Engineering and Architecture, the next step was to combine these two variables with each of the other subject tests. The College Aptitude Test was omitted from these correlations because in all previous calculations it has stood uniformly lowest of the variables in its contribution.

The summary of the results of these calculations (Table V) showed that high school scholarship, the Mathematics Training Test, and the English Aptitude Test combined produced the highest coefficients, .8173 with the first quarter honor point ratio and .7886 with the first year honor point ratio. These two coefficients were nearly as high as those

found for all the eight measures combined, the increase from the addition of the five other measures being only .019 for the first quarter and .011 for the first year. The analysis of the data seems to show that rank in scholarship in the high school graduating class and scores on the Mathematics Training Test and the English Aptitude Test will result in almost as valid a prediction as can be obtained from all eight variables combined.

TABLE V

MULTIPLE COEFFICIENTS OF CORRELATION BETWEEN FIRST QUARTER AND FIRST YEAR HONOR POINT RATIOS AND VARIOUS COMBINATIONS OF HIGH SCHOOL SCHOLARSHIP, MATHEMATICS TRAINING TEST, AND OTHER MEASURES, STUDENTS ENTERING FALL QUARTER, 1931, COLLEGE OF ENGINEERING AND ARCHITECTURE

VARIABLES	FIRST QUARTER HONOR POINT RATIO	FIRST YEAR HONOR POINT RATIO
High school scholarship, Mathematics Training, Mathematics Aptitude	.7904	.7773
High school scholarship, Mathematics Training, Chemistry Aptitude	.7900	.7769
High school scholarship, Mathematics Training, Chemistry Training	.7872	.7776
High school scholarship, Mathematics Training, English Aptitude	.8173	.7886
High school scholarship, Mathematics Training, English Training	.7919	.7874

As compared with the coefficients obtained in many other studies of prediction of college success, these coefficients are rather large. It should not be assumed too hastily, however, that these coefficients justify the use of these measures for the selection of individual students for admission to college. There are many factors other than those measured which contribute to college success. Some students who stand very high on these tests may fail in college work and others who stand low may succeed. These coefficients do indicate, however, that closer predictions can be made for the performance of the group, and that the chances of individual success can be approximated more closely.

EFFECT OF DEFICIENCY IN CERTAIN SECONDARY MATHEMATICS UPON SUCCESS IN THE COLLEGE OF ENGINEERING AND ARCHITECTURE

One of the recommendations made in connection with the Investigation of Engineering Education was that admissions with conditions be abolished as rapidly as possible.[1] In 1932 the College of Engineering and Architecture, University of Minnesota, changed its entrance requirements to conform to this recommendation. Altho higher algebra, one-half unit, and solid geometry, one-half unit, had long been required for entrance by this college, in practice students had been permitted to enter with conditions in these two subjects. To accommodate these conditioned students, courses in the two subcollege subjects were offered. Beginning with the school year 1932-33, the college discontinued these courses and adopted the practice of admitting only those students who could meet all entrance requirements including the courses in higher algebra and solid geometry.

The recommendation referred to above was based in a large measure upon the results of a series of investigations which showed that 60 per cent of the freshmen entering the College of Engineering and Architecture without conditions began the sophomore year, as compared with 38.5 per cent of those entering with conditions. The weakness of these studies is that there is nothing to show that these groups were equivalent in all respects, save that one group had taken certain mathematics in high school and the other had not. If one is to conclude that the failure to study certain mathematics in high school was largely responsible for elimination from college these groups must be equivalent in respect to all other factors. It is altogether possible that failure in college may be due to other causes.

It is well to note here one of the conclusions of an investigation conducted by Edgerton and Toops.[2] In this study made at Ohio University it was found that conditioned students did poorer college work than did the nonconditioned students. The authors attribute the inferior scholastic work of the conditioned students largely to the lower degree of intelligence of this group. They conclude "that the possession or nonpossession of conditions in college . . . is of little significance

[1] H. H. Jordan and others, "Report on Admissions and Eliminations of Engineering Students." *Proceedings of the Society for the Promotion of Engineering Education* (Iowa City meeting, 1926), 34:146. 1926.

[2] Harold A. Edgerton and Herbert A. Toops, *Academic Progress*. Columbus: Ohio State University Press. 1929.

as compared with the possession or nonpossession of high degrees of intelligence." Whether this conclusion can be applied specifically to students conditioned in solid geometry or higher algebra has not been investigated previously.

It is the purpose of this investigation to study the effect of deficiency in higher algebra and solid geometry upon success in the College of Engineering and Architecture. In this connection there are three important questions which we shall attempt to answer. They are: (1) how do the conditioned and nonconditioned students compare in ability to do college work? (2) how do these groups compare in success in college? and (3) when the conditioned students are matched with nonconditioned students of equal ability, how do these groups compare in success in college?

Ability to do college work was measured by four criteria: percentile rank in average scholarship in high school graduating class, percentile rank on the College Aptitude Test, and scores on the Mathematics Aptitude and Mathematics Training tests.

The criteria of success in college consisted of the honor point ratios for the first quarter and first year, and graduation from college.

All students entering the College of Engineering and Architecture during the four-year period 1928-29 to 1931-32, who came from Minnesota high schools, who were entering college for the first time, and for whom complete data were to be had were included in this study. Altogether there were 951 students of whom 262 entered with conditions and 689 without conditions.[3]

Differences between Conditioned and Nonconditioned Students on Measures of Initial Status

On the basis of the four criteria of initial ability the nonconditioned was superior to the conditioned group. As shown in Table I, the mean scores of the former were larger than those of the latter on all four criteria. Furthermore, the differences between the means of the two groups were statistically significant in every instance.[4]

[3] A large number of the students who pursued higher algebra in college had previously taken this subject in high school. Students in the college classes in college algebra were given a test after two weeks of review of higher algebra. Those students making a poor showing on the examination were recommended to repeat advanced algebra in college.

Students taking the two subcollege subjects in college can be classified into five groups, namely: (1) those enrolled in both higher algebra and solid geometry who were deficient in both subjects; (2) those enrolled in higher algebra and solid geometry who were deficient only in solid geometry; (3) those enrolled in solid geometry who were deficient in this subject; (4) those in higher algebra who were deficient in this subject; and (5) those in higher algebra who were not deficient. In addition to these five groups, there was the group of nonconditioned students who had taken higher algebra and solid geometry in high school and did not repeat them in college. Those who are interested in a detailed analysis of the initial status and success in college of these six groups are referred to the unpublished study, "A Study of the Entrance Requirements to the College of Engineering," by A. S. Northby, Library, University of Minnesota.

[4] The common practice is to require the difference between two means to be equal to three times the standard error of the difference between the means to be statistically significant, i.e., not due to chance errors of measurement.

TABLE I

Ratios of the Difference between Means to the Standard Error of the Difference and Related Data, College Aptitude Test, Percentile Rank in High School Graduating Class, Mathematics Aptitude Test, and Mathematics Training Test, Combined Conditioned and Nonconditioned Groups

Measure	N	Mean	S.D.	S.E.	Ratio $D/S.E._D$
College Aptitude Test:					
Conditioned	262	42.45	27.97	1.728	3.04
Nonconditioned	689	48.73	29.55	1.125	
High school scholarship:					
Conditioned	262	54.51	26.04	1.609	5.012
Nonconditioned	689	63.94	25.60	0.975	
Mathematics Aptitude Test:					
Conditioned	262	27.15	9.53	0.588	9.208
Nonconditioned	689	33.65	10.29	0.392	
Mathematics Training Test:					
Conditioned	262	27.89	10.13	0.626	16.36
Nonconditioned	689	40.03	10.50	0.399	

The two groups were more alike on the two measures of general ability, the College Aptitude Test and percentile rank in high school scholarship, than on the two measures of mathematical ability, the Mathematics Aptitude and Mathematics Training tests. Since the nonconditioned students had taken one-half to one or more years of high school mathematics more than the conditioned students, greater differences on the mathematics tests than the other two criteria are to be expected.

One should not assume that since the averages of the nonconditioned group were greater in every instance the individuals composing this group were uniformly superior to those of the other. A brief comparison of the standard deviations with reference to the related means suggests that the distributions overlapped considerably, that many of the conditioned students were superior to many of the nonconditioned. To determine more definitely the extent of the overlapping the per cent of each group falling below and exceeding the median of the other group on the four measures was calculated. The results are presented in Table II. On the College Aptitude Test, 41.7 per cent and on the percentile rank in high school scholarship, 34.4 per cent of the conditioned students exceeded the median of the nonconditioned. The overlapping on the two mathematics tests was less. On the Mathematics Aptitude Test, 24.1 per cent and on the Mathematics Training Test, 13.4 per cent of the conditioned exceeded the median of the nonconditioned.

TABLE II

PER CENT OF THE NONCONDITIONED GROUP EXCEEDING AND FALLING BELOW THE MEDIAN OF THE CONDITIONED GROUP, AND THE PER CENT OF THE CONDITIONED GROUP EXCEEDING AND FALLING BELOW THE MEDIAN OF THE NONCONDITIONED GROUP, FOUR CRITERIA OF INITIAL STATUS

CRITERION	MEDIAN OF CONDITIONED		MEDIAN OF NONCONDITIONED	
	Per Cent Below	Per Cent Exceeding	Per Cent Below	Per Cent Exceeding
College Aptitude Test:				
Conditioned	50.0	50.0	58.3	41.7
Nonconditioned	41.8	58.2	50.0	50.0
Percentile rank in high school scholarship:				
Conditioned	50.0	50.0	65.6	34.4
Nonconditioned	34.9	65.1	50.0	50.0
Mathematics Aptitude Test:				
Conditioned	50.0	50.0	75.9	24.1
Nonconditioned	27.4	72.6	50.0	50.0
Mathematics Training Test:				
Conditioned	50.0	50.0	86.6	13.4
Nonconditioned	10.8	89.2	50.0	50.0

As measured by the three criteria of college success, i.e., first quarter and first year honor point ratios and graduation from college, the nonconditioned group did better college work than the conditioned. Such a result is to be expected in view of the superior ability of the former group. The mean first quarter honor point ratios for the conditioned and nonconditioned groups were 116.14 and 151.97, respectively (Table III). The two groups differed less on the first year honor point ratios. The mean ratio of the conditioned students was 143.83 as compared with 166.38 for the nonconditioned. One need not look far for the cause of the decrease in the difference between the first quarter and first year honor point ratios. A study of the individual records showed that most of the cases dropping out were those doing inferior college work, and that the percentage of these failure students was larger for the conditioned than for the nonconditioned group. Approximately 70 per cent of the 179 students who did not complete three quarters of work received first quarter honor point ratios in the 0 to 100 range, equivalent to a letter mark of D or less; and 34 per cent of the conditioned students did not complete three quarters of college attendance as compared with 15 per cent of the nonconditioned. The difference between the first year honor point ratios as well as that between first quarter honor point ratios was statistically significant.

The overlapping of the two groups on both of the honor point ratios was as great as that found with the criteria of initial ability. With

reference to the first quarter honor point ratios 26.7 per cent of the nonconditioned fell below the median of the conditioned. The overlapping was greater on the first year honor point ratios (Table IV). Here 37.2 per cent of the nonconditioned fell below the median of the conditioned.

TABLE III

MEAN FIRST QUARTER AND FIRST YEAR HONOR POINT RATIOS OF THE CONDITIONED AND NONCONDITIONED GROUPS, TOGETHER WITH THE RATIO OF THE DIFFERENCE BETWEEN MEANS TO THE STANDARD ERROR OF THE DIFFERENCE AND RELATED DATA

HONOR POINT RATIO	N	MEAN	S.D.	S.E.	RATIO $D/S.E._D$
First quarter honor point ratio:					
Conditioned	262	116.14	80.64	4.982	6.209
Nonconditioned	689	151.97	76.39	2.910	
First year honor point ratio:					
Conditioned	173	143.83	57.85	4.398	4.353
Nonconditioned	599	166.38	67.03	2.738	

On the third measure of college success, i.e., graduation from college, the nonconditioned students were again superior. Data were available regarding only the first two of the four classes included in this study—those entering in 1928 and in 1929. By December, 1933, over five years after entrance to college, 11, or 16.1 per cent, of the conditioned students in the 1928 entering classes compared with 56, or 37.6 per cent, of the nonconditioned students in the same entering class had received degrees. The difference between the two groups is even greater in the 1929 entering class. In this instance, by December, 1933, or slightly more than four years after entering college, 47, or 26.5 per cent, of the nonconditioned students had received degrees as compared with 3, or 3.8 per cent, of the conditioned students.

In the preceding sections it was observed that the students entering without conditions did college work superior to that done by those entering with conditions. The former group was also superior in ability as measured by the College Aptitude Test, percentile rank in high school scholarship, and the Mathematics Aptitude and Mathematics Training tests. In order to determine to what extent the college success of the students entering with conditions differs from that of students of the same ability but entering without conditions, three series of paired studies were made. Students who were conditioned in higher algebra or in solid geometry or in both of these subjects were paired with students who entered without conditions and who took neither of the two sub-

college subjects in college. The first quarter and first year honor point ratios of the resulting groups were then compared. The cases were matched on both percentile score on the College Aptitude Test and percentile rank in high school scholarship. An unsuccessful attempt was made to match the groups on a third criterion, the Mathematics Aptitude Test. It should be noted here that the inability to match the pairs on scores on this test may mean that they were not equated, since there is, of course, the possibility that the differences between the groups were due largely to differences in mathematics aptitude as might be measured by the Mathematics Aptitude Test. For convenience, the students with conditions will be designated as the experimental group and the students without conditions as the control group.

TABLE IV

PER CENT OF THE NONCONDITIONED STUDENTS EXCEEDING AND FALLING BELOW THE MEDIAN OF THE CONDITIONED STUDENTS, AND THE PER CENT OF THE CONDITIONED STUDENTS EXCEEDING AND FALLING BELOW THE MEDIAN OF NONCONDITIONED STUDENTS, FIRST QUARTER, AND FIRST YEAR HONOR POINT RATIOS

Ratio	Median Conditioned Group		Median Nonconditioned Group	
	Per Cent Below	Per Cent Exceeding	Per Cent Below	Per Cent Exceeding
First quarter honor point ratio:				
Conditioned	50.0	50.0	67.2	32.8
Nonconditioned	26.7	73.3	50.0	50.0
First year honor point ratio:				
Conditioned	50.0	50.0	64.9	35.1
Nonconditioned	37.2	62.8	50.0	50.0

It was found possible to match 149 of the 162 students who entered with conditions in both higher algebra and solid geometry, with students who entered without conditions, using both the College Aptitude Test and high school scholarship as bases for pairing.

Since it was impossible to match all experimental subjects with control subjects having identical scores on the two criteria, they were matched as closely as possible. Slight differences occurred between the matched pairs, but none of these differences exceeded 6 points on the College Aptitude Test or 7 points on high school scholarship. The average of the differences between the 149 matched pairs was only 1.43 points on the College Aptitude Test and but 2.03 points on high school scholarship. The means and standard deviations of the two groups on both criteria were nearly the same (Table V).

TABLE V

DATA RELATING TO FIRST QUARTER HONOR POINT RATIOS OF PAIRED GROUPS, EXPERIMENTAL GROUP ENTERED WITH CONDITIONS IN HIGHER ALGEBRA AND SOLID GEOMETRY, AND CONTROL GROUP ENTERED WITHOUT CONDITIONS, 149 PAIRS

Group	College Aptitude Test		Percentile Rank in High School Scholarship		First Quarter Honor Point Ratio	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Experimental	40.36	28.06	57.11	24.56	114.12	83.90
Control	40.25	28.21	57.36	24.35	137.10	72.74

$$S.E._{C.-E.} \text{ (First quarter honor point ratio) } 7.52 \frac{D.}{S.E._{D.}} = 3.055$$

The mean first quarter honor point ratio for the control group, composed of those entering without conditions, was 137.10 as compared with 114.12 for the experimental group composed of those entering with conditions in both advanced algebra and solid geometry. Altho the difference was not as great as previously observed with the unselected groups (Table I), it is still large enough to be statistically significant.[5]

In studying the first year honor point ratios of the experimental and control groups we matched 90 pairs on both the College Aptitude Test and on the percentile rank in high school scholarship.[6]

The matching was again close, the mean of the differences between matched pairs was 1.32 points on the College Aptitude Test and 1.99 points on the percentile rank in high school scholarship. The means and standard deviations of the two distributions were practically identical (Table VI).

The mean honor point ratio for the first year of the control group again exceeded that of the experimental group—161.57 as compared with 143.98. The difference between the two means was not statistically significant, altho it approached it, the critical ratio being 2.37.

In summarizing the results found, we find that altho the groups were matched in order to eliminate differences in general ability, the control group, composed of students entering without conditions, did superior college work to the experimental group composed of students who entered with conditions in both advanced algebra and solid geometry. If the groups were equated in all respects the college success of the two would, of course, have been the same. Evidently some factor

[5] In all instances where the means of matched groups were compared "Student's Method" was used to measure the significance of the difference between means. See Mordecai Ezekiel, "Student's Method for Measuring the Significance of a Difference between Matched Groups," *Journal of Educational Psychology*, 23:445-50. September, 1932.

[6] Of the 162 students who originally composed the experimental group, 98 were in attendance three or more quarters, the other 64 having dropped out.

which was not fully measured by the College Aptitude Test or the percentile rank in high school scholarship was operative in determining college success. Since the difference between the two groups was primarily that one group (the control) had pursued more mathematics in high school than did the other (the experimental) it appears reasonable to assume that the students in the former group had a special liking or capacity for mathematics, and that this factor influenced their success in college. Furthermore, success in the College of Engineering and Architecture, especially any measure of success based on the first year's work, is closely related to success in mathematics.

TABLE VI

DATA RELATING TO FIRST YEAR HONOR POINT RATIOS OF PAIRED GROUPS, EXPERIMENTAL GROUP ENTERED WITH CONDITIONS IN HIGHER ALGEBRA AND SOLID GEOMETRY, AND CONTROL GROUP ENTERED WITHOUT CONDITIONS, 90 PAIRS

GROUP	COLLEGE APTITUDE TEST		PERCENTILE RANK IN HIGH SCHOOL SCHOLARSHIP		FIRST YEAR HONOR POINT RATIO	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Experimental	45.26	29.65	62.89	23.84	143.98	60.28
Control	45.20	29.78	63.07	23.83	161.57	64.61

$S.E._{C.-E.}$ (First year honor point ratio) $7.43 \frac{D.}{S.E._{D.}} = 2.37$

The second series of paired studies to be considered included as the experimental group the students who entered with conditions in advanced algebra. Each of the 26 cases included in this group was paired with an individual who entered without conditions and who took neither advanced algebra nor solid geometry in college. The matching was made on both the College Aptitude Test and percentile rank in high school scholarship. The mean of the differences between the matched pairs was 1.50 points on the College Aptitude Test and 2.54 points on the high school scholarship. The means and standard deviations of the two groups on these two measures were almost identical (Table VII).

The mean first quarter honor point ratio for the control group was 148.78 as compared with 126.31 for the experimental group. The difference between these two means was not statistically significant, however, as the critical ratio was but 1.78 (Table VII).

Of the 26 students included in the study of the first quarter honor point ratios, 21 were in attendance three or more quarters. The dropping out of the 5 cases did not appear to affect the means or standard deviations on the College Aptitude Test or percentile rank in high school scholarship of the two groups (Table VIII). A comparison of the

means of the first quarter groups with those of the first year groups shows little change. The means on the College Aptitude Test decreased slightly while the means on the percentile rank in high school scholarship increased slightly.

TABLE VII

DATA RELATING TO FIRST QUARTER HONOR POINT RATIOS OF PAIRED GROUPS, EXPERIMENTAL GROUP ENTERED WITH CONDITIONS IN HIGHER ALGEBRA, AND CONTROL GROUP ENTERED WITHOUT CONDITIONS, 26 PAIRS

GROUP	COLLEGE APTITUDE TEST		PERCENTILE RANK IN HIGH SCHOOL SCHOLARSHIP		FIRST QUARTER HONOR POINT RATIO	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Experimental	43.15	28.04	56.04	21.97	126.31	72.51
Control	43.04	27.88	56.15	21.96	148.78	71.65

$S.E._{C.-E.}$ (First quarter honor point ratio) $12.58 \frac{D.}{S.E._{D.}} = 1.78$

The mean first year honor point ratio of the control group was again higher than that of the experimental group—156.62 as compared with 145.57 (Table VIII). The critical ratio, .67, indicates that the difference between these two means cannot be considered statistically significant.

TABLE VIII

DATA RELATING TO FIRST YEAR HONOR POINT RATIOS OF PAIRED GROUPS, EXPERIMENTAL GROUP ENTERED WITH CONDITIONS IN HIGHER ALGEBRA, CONTROL GROUP ENTERED WITHOUT CONDITIONS, 21 PAIRS

GROUP	COLLEGE APTITUDE TEST		PERCENTILE RANK IN HIGH SCHOOL SCHOLARSHIP		FIRST YEAR HONOR POINT RATIO	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Experimental	42.19	28.28	57.38	22.66	145.57	51.84
Control	42.19	27.84	57.19	22.49	156.62	70.72

$S.E._{C.-E.}$ (First year honor point ratio) $16.42 \frac{D.}{S.E._{D.}} = .67$

In both of the comparisons just made the control group composed of students who entered without conditions did superior work to that of the experimental group composed of students who entered with conditions in advanced algebra. Neither of the two differences between means was statistically significant. The lack of high reliability can be attributed in part to the small numbers included.

The third set of comparisons was concerned with the students conditioned in solid geometry. It was found possible to match 33 of the 34 cases in this group with individuals who entered without conditions,

on the two criteria, College Aptitude Test and percentile rank in high school scholarship. The closeness with which the experimental and control groups were equated is shown by the similarity of their means and standard deviations which are assembled in Table IX. The mean of the differences between 33 pairs on the College Aptitude Test was 1.39 points, and on the percentile rank in high school scholarship 2.06 points.

TABLE IX

DATA RELATING TO FIRST QUARTER HONOR POINT RATIOS OF PAIRED GROUPS, EXPERIMENTAL GROUP ENTERED WITH CONDITIONS IN SOLID GEOMETRY, AND CONTROL GROUP ENTERED WITHOUT CONDITIONS, 33 PAIRS

GROUP	COLLEGE APTITUDE TEST		PERCENTILE RANK IN HIGH SCHOOL SCHOLARSHIP		FIRST QUARTER HONOR POINT RATIO	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Experimental	47.09	25.23	55.94	25.72	134.42	44.36
Control	47.03	25.64	56.27	25.64	134.36	44.34

$S.E._{C.-E.}$ (First quarter honor point ratio) $17.976 \quad \frac{D.}{S.E._{D.}} = .0034$

A comparison of the mean first quarter honor point ratio of the experimental with that of the control group reveals practically no difference between the two—134.42 for the former and 134.36 for the latter (Table IX).

In the comparison of mean first year honor point ratios 26 of the cases used in the preceding analysis were included. The dropping out of the seven cases did not change the means or standard deviations on the two criteria used for matching (Table X). A comparison of the two mean first year honor point ratios reveals a slight superiority in the control group over the experimental, the mean ratio for the former being 149.12 and for the latter 144.31. This slight difference is by no means statistically significant, as indicated by the critical ratio of .456.

TABLE X

DATA RELATING TO FIRST YEAR HONOR POINT RATIOS OF THE PAIRED GROUPS, EXPERIMENTAL GROUP ENTERED WITH CONDITIONS IN SOLID GEOMETRY, AND CONTROL GROUP ENTERED WITHOUT CONDITIONS, 26 PAIRS

GROUP	COLLEGE APTITUDE TEST		PERCENTILE RANK IN HIGH SCHOOL SCHOLARSHIP		FIRST YEAR HONOR POINT RATIO	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Experimental	47.19	25.98	60.69	24.45	144.31	53.67
Control	47.62	26.30	60.96	24.45	149.12	67.72

$S.E._{C.-E.}$ (First year honor point ratio) $10.529 \quad \frac{D.}{S.E._{D.}} = .456$

It is clearly evident from these results that, as far as these students are representative of the entire group, there is little, if any, difference between the college success of those entering with a condition in solid geometry and those entering without. These data are in contrast to those obtained with the group entering with conditions in both advanced algebra and solid geometry and in advanced algebra only. In the comparisons made with the latter two groups it was shown that those entering with conditions did inferior work to that done by those entering without conditions. It should be remembered that in only one instance, however, was the critical ratio large enough to indicate high reliability.

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TITLE